



Application of Agile for Systems Engineering, Project Management and Modeling Lessons Learned

HRP Investigator's Workshop
February 2022

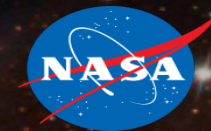
S Lumpkins*, D Goodenow*, J Cohen, E Griffin, T Rakalina, D Rubin, G Powers, J Heiser, K McGuire

**Co-first authors*





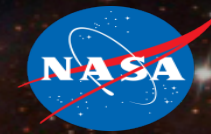
Overview



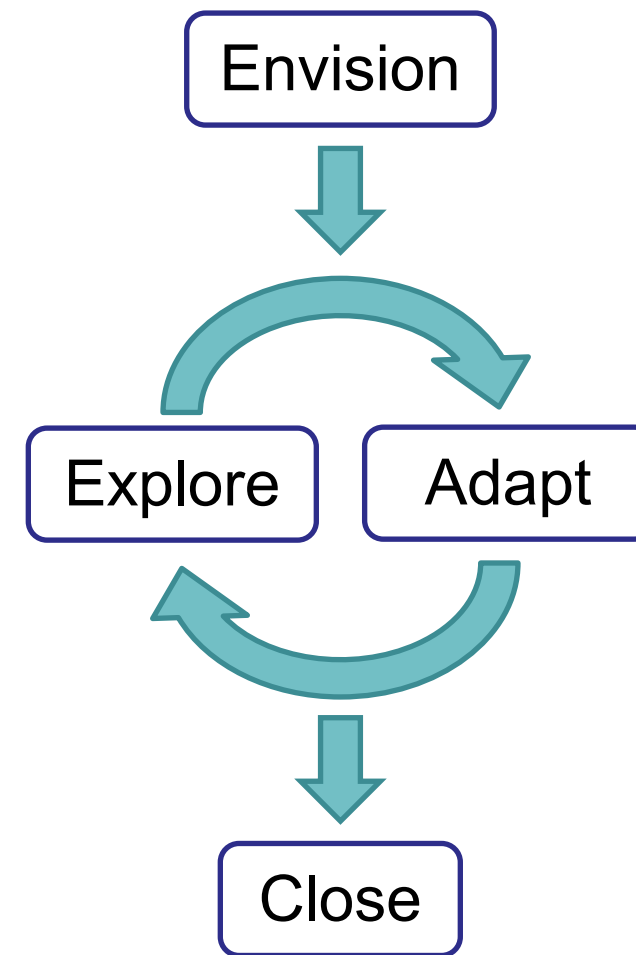
- Introduction to the agile methodology
- Agile use case: IMPACT
- Agile use case: Long-Duration Medical System Foundation
- Lessons learned
- Future Work

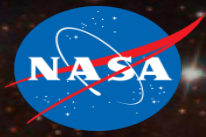


Introduction to Agile



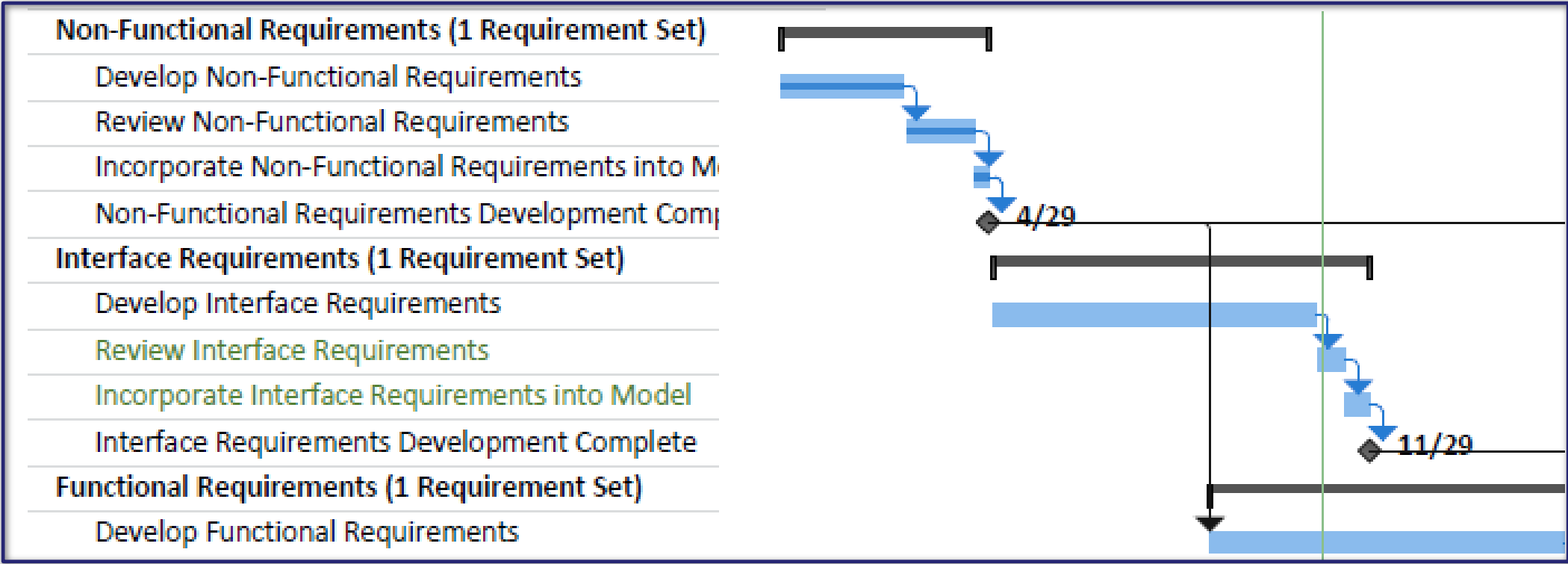
- Customer focused and requires regular customer feedback.
- Customer involved in determining features and prioritization.
- Development team provides periodic **and frequent** demonstrations to seek customer feedback.
- Frequent delivery of intermediate results.
- Customer involved in acceptance testing and close out.
- Initially developed for software projects, but this presentation will demonstrate its application within one organization to two different types of projects





Traditional Waterfall Approach

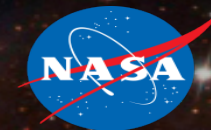
- Products are worked on in a sequential manner
- There is no iterative feedback loop between the steps



Example waterfall schedule



Agile Approach



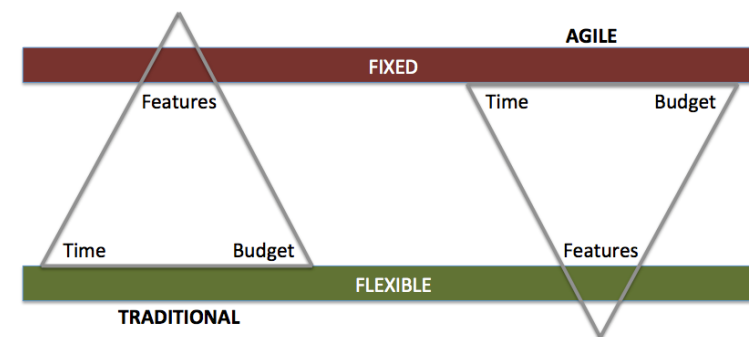
- Highest priority is to satisfy the customer through early and continuous delivery of valuable products.
- Welcome [accept] changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
- Deliver portions of the product frequently, from a couple of weeks to a couple of months.
- Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
- Continuous attention to technical excellent and good design enhances agility.
- At regular intervals, the team reflects on how to become more effective, then fine tunes and adjusts its behavior accordingly.

The Agile Manifesto

Individuals and interactions	over	Processes and Tools
Working Product	over	Comprehensive Documentation
Customer Collaboration	over	Contract Negotiation
Responding to change	over	Following a plan

That is, while there is value in the items on the right, we value the items on the left more.

www.agilemanifesto.org



Source: Dave Rice PMP
Dave@DRiceconsulting.com



Application of the Agile Framework to IMPACT



What is IMPACT?



IMPACT is a set of functions!

- Executed by a suite of computational and systems engineering tools
- Informing the decision making process for the development of human health and performance systems
- Currently being developed for ExMC to address the medical system

Initially, we want to answer medical questions like these:

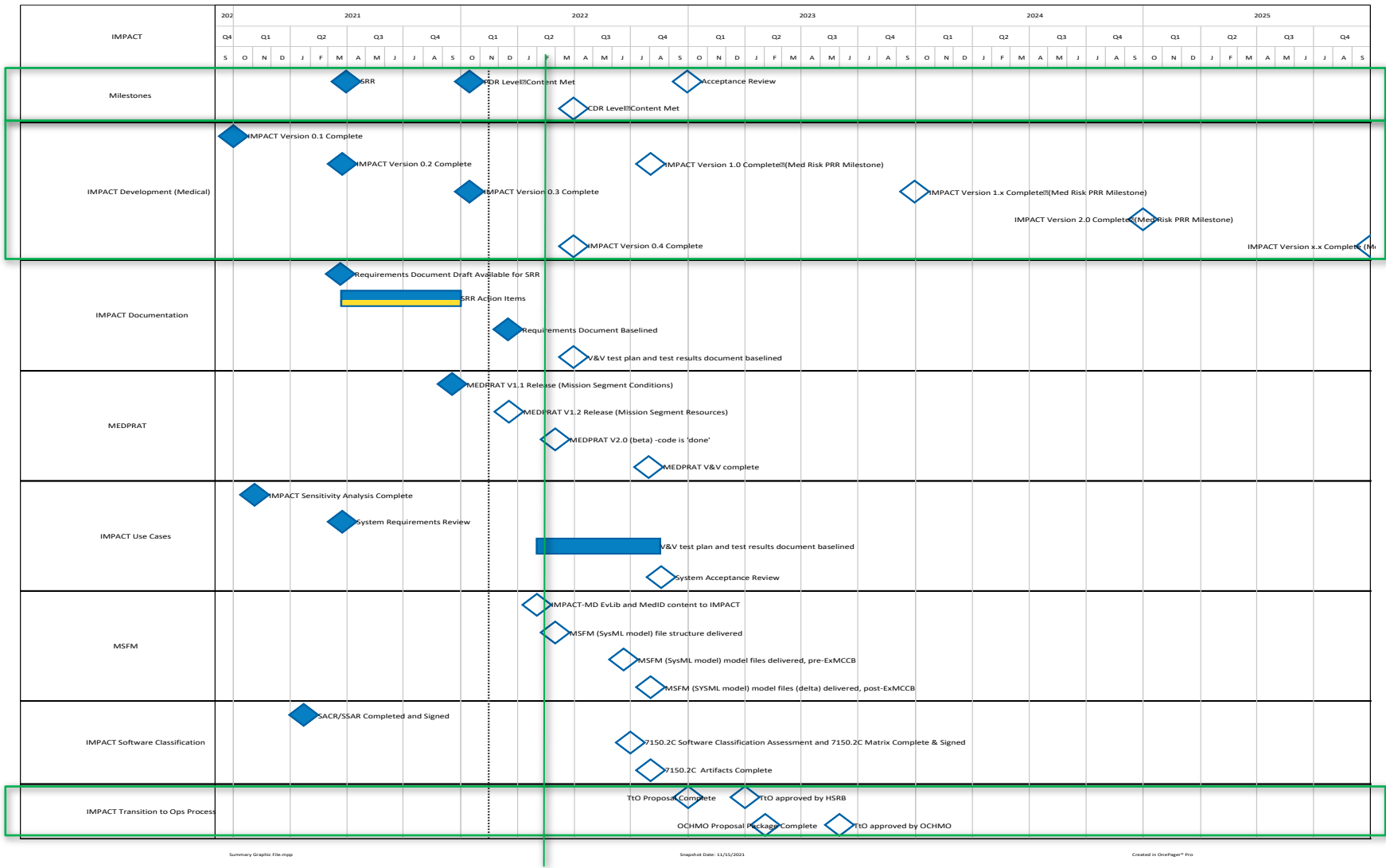
- What medical conditions are likely to occur on specific mission to a particular crew?
- What set of medical capabilities best mitigate risk for a given mass/volume allocation on a specific mission? What if that number is halved?
- If I could reduce the mass or volume of hardware X by 50%, would it be sufficient to manifest? Would developing a new medical intervention for spaceflight that treats 3 different conditions be a better investment?

Eventually, we want to answer questions like these:

- Does 1 kg of meds or water or an AED best reduce health risks?
- What is the benefit of changing crew's water rations from 2 to 3L daily on health risk?

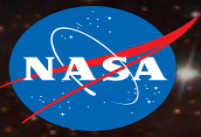


IMPACT Schedule

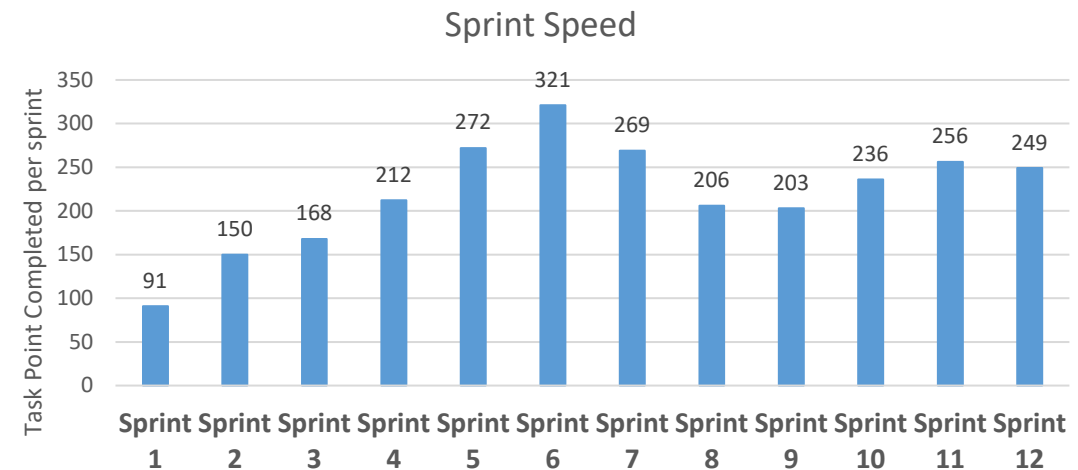
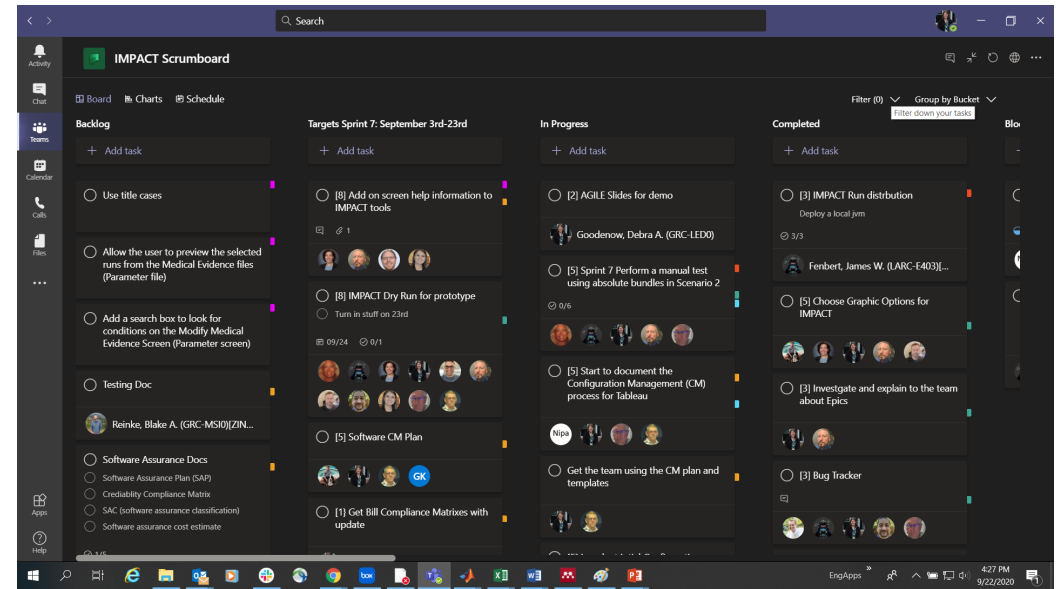




Agile and our Scrum Implementation

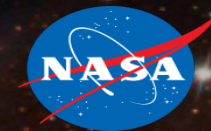


- **Month long sprints** are windows of development effort, punctuated by frequent interface with customers and users to get feedback.
- **Agile Epics –NASA Con-ops scenarios** are big picture features focuses on early description of use and desired capabilities that are evaluated for development priority by the project lead.
- **Quarterly Demonstrations** illustrate implementation and testing of new capabilities and denotes delivery of a working version for user testing.
- **Throughout each sprint** we cover development, software testing, user testing, and documentation of products.
- **Regular stand up meetings** improve coordination, prevent siloing, and keep the project focused





Month Long Sprints



- Sprint Planning

- What can be done in a month
- Team members **make their own tasks not management** based on what they need to do to implement the scenarios
 - More accurate more likely to include steps and details that make sense to the team members
 - Team members update their own cards and can add new ones throughout as unexpected tasks come
 - Example unexpected database server migration or update

- Sprint Review

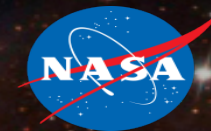
- Move unfinished stories to the product backlog.
- Review task completion.
- Move completed cards to sprint history
 - Partially completed cards can be split and things that still be done moved to the backlog
- Agree as a team what was “done”.
- Discuss any outliers.

- Sprint Retrospective

- time to review the team’s working practices and processes to ensure they are as efficient as possible.
 - What went well?
 - What could have gone better?
 - What could be improved upon in the next sprint?
- There should always be things that can be improved.
- Focus on issues like sprint length, realistic expectations, new soft and technical skills needed, new efficiencies, how we can work smarter



Rating System*



- [1] – Quick Email**
- [2] – Email you have to edit and have someone else look at before you send it**
- [3] – Small 3 people task, maybe like a small meeting**
- [5] - Larger tasks multiple meetings, multiple things to do spread out over the entire sprint**
- [8] – Lots of stuff to do, lots of people to coordinate with, probably multiple meetings probably will not get all done in one sprint**
- [13] – Large Group task ex. Everyone preps for multiple IWS presentations and meetings**
- [21] [144] –Death Star**

Uses a modified Fibonacci Sequence 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144

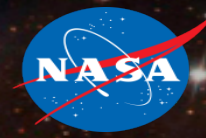
Whatever rating system the team likes. You can even use it with work hours

The point is to get people to stop and think about the task ahead of time, and in the process find places where they need help and potential pitfalls. And this communicates that to the rest of the team.

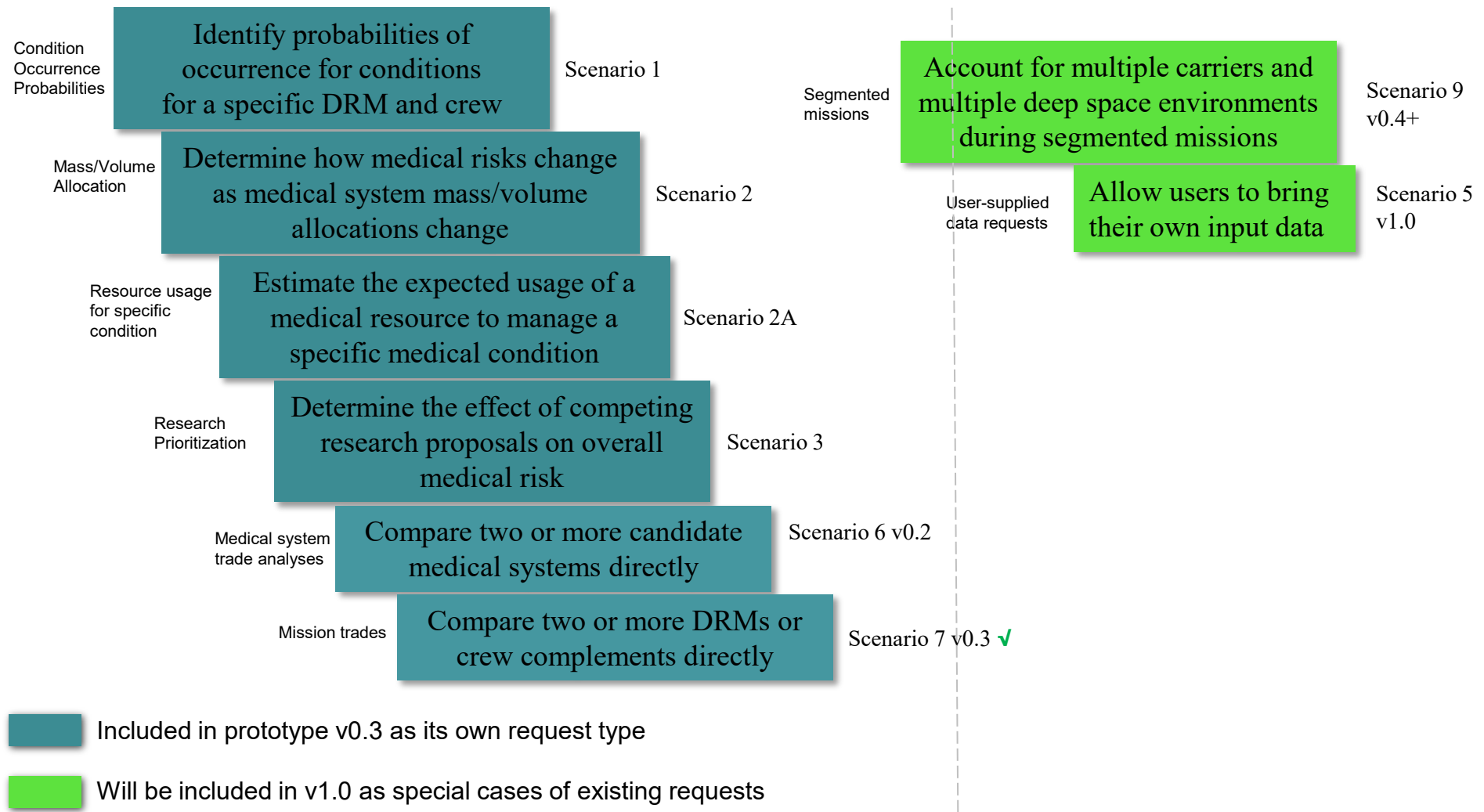
**was created by an introvert*



Using Con-Ops Scenarios as AGILE Epics

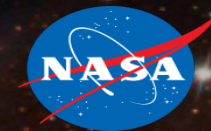


- Implementation of use cases from the IMPACT ConOps progressing to v1.0





Lessons Learned-Ideas from Sprint Retrospectives

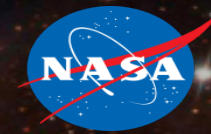


Sprint Retrospectives are wonderful sources of innovation-your team comes up with great ideas use them

- Have an internal team demo of the code once a month, this improves internal team communication and lets the developers show what they've been working on to the entire team
- With a large team dividing up into multiple sprint review, sprint planning, meetings helped. **AGILE works best when you have 7+/- 2 people.** Little meetings with the people who need to be in them is better than one huge one. We have ~26 people on impact who are part of our regular scrums. So we divided them into 3 groups and our meetings are much easier.
- **The best feedback sessions are the smaller ones right after the big demos**
 - People don't want to speak up in a big 40+ or bigger person meeting even if they are management
 - We had small meetings of 4-7 people with key groups of stakeholders afterward. Facilitated by human factors with a set list of questions to facilitate discussion and with the tech lead there to listen and answer any technical questions that came up.



Lessons Learned-General



General Lessons Learned

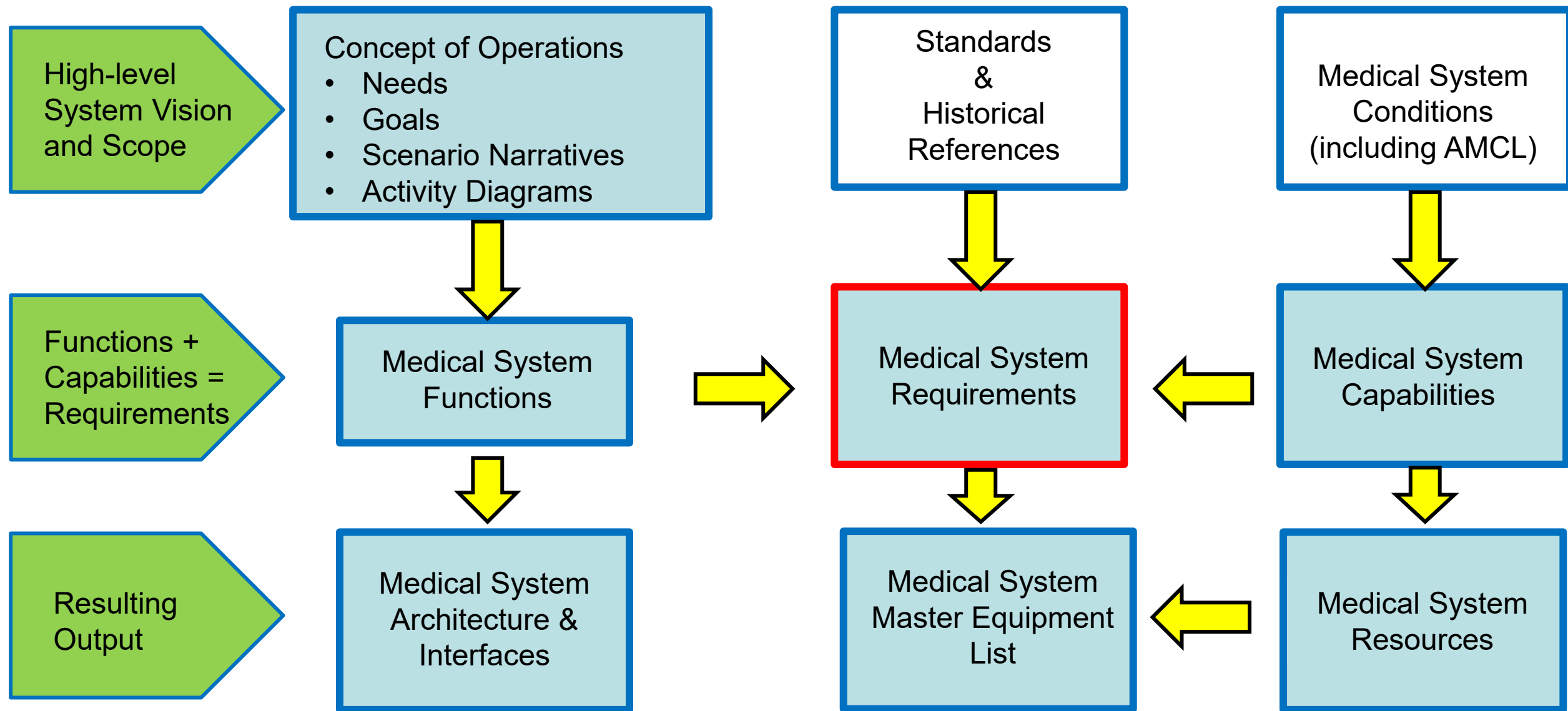
- **Con-ops Scenarios-** Make good AGILE epics
- **Let your team set the tasks**, and PM team the overall direction. You're not the expert in database coding, they are
- **Getting NASA people out of a very waterfall mindset for reviews is hard.**
 - Make sure you get that clear first.
 - Your requirements document can become more of a checklist for V &V than something you work to. This has not lead to scope creep, because of the regular communication.
- Cards are very useful when you have employee turnover
 - They provide a list of tasks that were being worked right before the person left and upcoming ones
- **It's a lot faster and more responsive than waterfall**
 - Multiple team members worked both IMM (waterfall) and MEDPRAT (AGILE)
 - "It's the difference between crawling and running and what you produce is what the customer actually wants." Deb Goodenow, IMM Coder and now IMPACT Technical Lead



Application of the Agile Framework to the Long-Duration Medical System Foundation

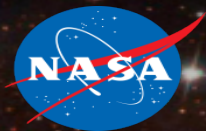
- The **Level of Care IV Long-Duration Lunar Orbit and Surface Operations Medical System Foundation** represents a recommended medical system for crew medical care on missions in lunar orbit and on the surface with durations **up to 9 months** and designated as **Level of Care IV**, as defined in NASA-STD-3001 Volume 1 and Volume 2 and as interpreted by ExMC*
- It provides a starting point for new medical system development efforts to understand potential medical system needs for a Level of Care IV system and was designed to:
 - enable users to view the medical functions, conditions, capabilities, and resources in a system model and how they all trace to medical system recommended requirements
 - assess the impact of removing medical resources via traces to the functions, capabilities, and conditions
 - provide content that can be tailored to specific missions
- The Foundation is neither hardware nor software; it is instead a framework that can be used for the development of a mission-specific medical system and could eventually be used in HW or SW development

* *“Interpretation of NASA-STD-3001 Levels of Care for Exploration Medical System Development”*. For a more detailed discussion of the ConOps for this Foundation, please see MS Kaetzer’s presentation: **Implementation of a SysML model-based Concept of Operations in the Long Duration Foundation Project**





Agile Implementation in Medical System Foundation Work



- **ExMC SE adopted the agile scrum framework**
 - Project tasks are identified
 - Tasks are organized into sprints
- **Sprint Description**
 - Fixed time period for performing set of tasks (2 weeks)
 - Extended project team determines the tasks to be performed each sprint
 - Tasks are recorded in cards on the MS Teams Planner Board
 - Team members move task cards to the corresponding sprint's 'completion' bucket as tasks are completed

Sprint 10 (5/7-5/20) Completed

+ Add task

☒ Completed recurrent pattern activiti... diagrams

☐ incorporate non-functional requirements in model

☐ Begin dispositioning comments from internal review

Sprint 9 (4/23-5/6) Completed

+ Add task

☐ TO DO for INTERNAL REVIEW

☐ complete video guide for model

☐ complete parameter table update (Mary Susa)

☐ Make sure all narratives have been updated i

☐ Add version # and date on the UI

☐ Update names of swimlanes

✓ 0/5

Scenario Developm...

☐ Prepare Medical Kit Scenario

☐ Update narrative in model (SE)

☐ Create activity diagram in model (Modeler)

☐ Review activity diagram (Modeler + SE)

☐ Review activity diagram (Lumpkins)

☐ Update activity diagram (Modeler)

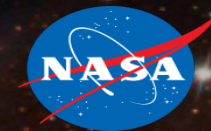
☐ Review narrative and activity diagram (CST/S

☐ Update narrative and activity diagram (SE / M

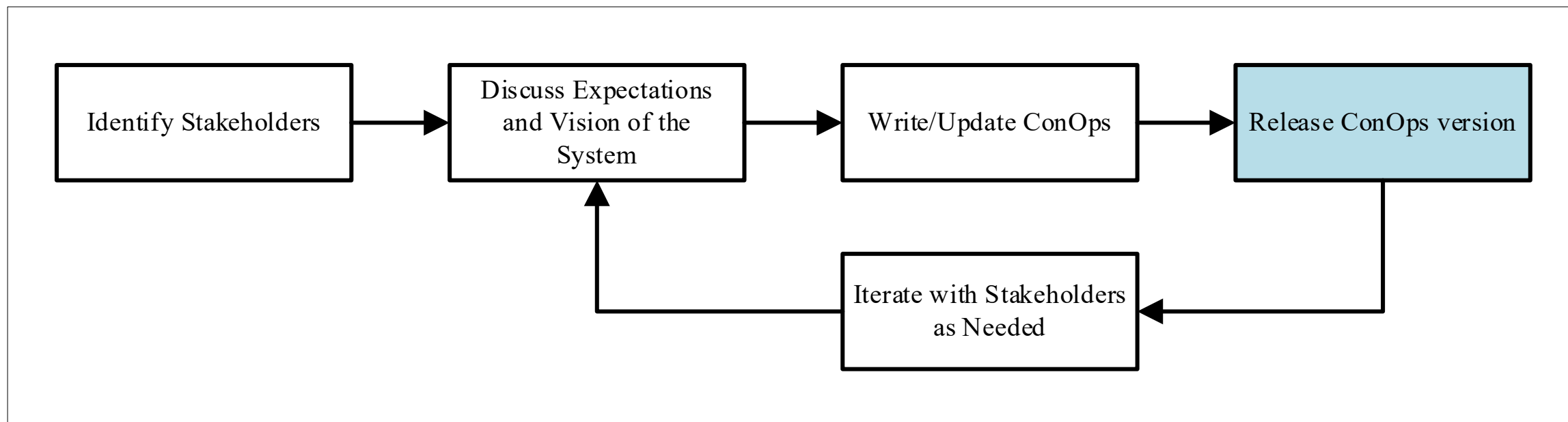
☐ Review narrative and activity diagram (Found



Agile Implementation in Medical System Foundation Work



- Iterative feedback loop with the stakeholders was employed to verify that the SEs' understanding of the functionality met the stakeholders' expectations.





Lesson Learned: Managing a Waterfall Schedule in an Agile Development Environment



- **Traditional waterfall schedule approach**

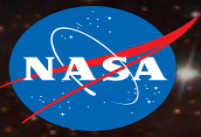
- Used to track competing milestones and deliverable timelines across the SE team and non-SE system stakeholders (e.g., clinicians and management)
- Integrated schedule lists tasks granularly and in a prescribed order
- This approach enables the best estimate of when work would be complete and level of effort/number of people required to complete tasks (essential for integrating work of multiple teams)

- **Agile approach**

- Allows flexibility to perform work as people with necessary expertise become available
- Provides a mechanism for SEs to begin another task if previous tasks are completed in less time than budgeted
- Project status reporting is provided in the context of how project-level task completion progress impacts (or not) Program-level milestones.



Lesson Learned: Problems with Sprints



- Initially, task cards were created to document all steps required to complete a task via the checklist feature. However, the following issues were identified:
 - All the task steps generally couldn't be completed in a single sprint (e.g., reviews by non-SE team stakeholders)
 - MITIGATION: Task cards were moved to the subsequent sprint
 - Task cards did not provide sufficient detail to track daily progress of the project's various teams
 - MITIGATION: Secondary Planner boards were created specifically for project sub-teams. Dual-card process provided all team members with sufficient level of detail necessary to perform tasks

☐ Prepare Medical Kit Scenario

Scenario Development

Bucket: Sprint 9 (4/23-5/6) Compl...

Progress: In progress

Priority: Medium

Start date: 01/19/2021

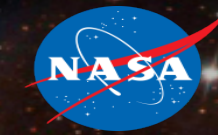
Due date: Due anytime

Notes

Narrative: Mary Susan
Activity Diagram: Jeremy

Checklist 4 / 12

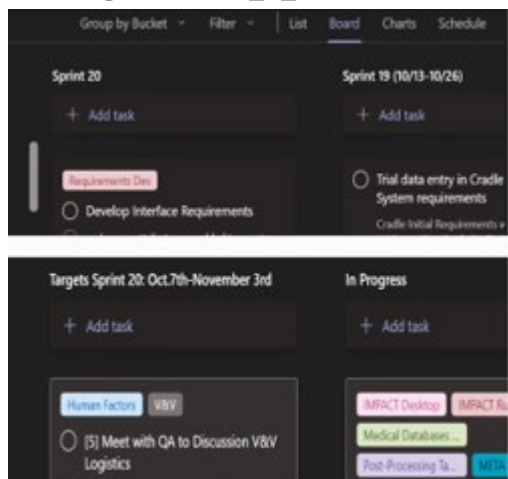
- ☒ [3] Write Narrative
- ☒ [2] Review narrative (Lumpkins)
- ☒ [2] Update narrative (SE)
- ☒ Review narrative (CST)
- ☐ Update narrative in model (SE)
- ☐ Create activity diagram in model (Modeler)
- ☐ Review activity diagram (Modeler + SE)
- ☐ Review activity diagram (Lumpkins)
- ☐ Update activity diagram (Modeler)
- ☐ Review narrative and activity diagram (CST/SME)
- ☐ Update narrative and activity diagram (SE / Modeler)
- ☐ Review narrative and activity diagram (Foundation Lead)
- ☐ Add an item



Future Work

- Determine how to effectively and programmatically link the high- and low-level task boards
 - Consider moving from MS Teams Planner to Jira/Gitlab, which offer more capabilities
- Determine how to continue using an agile process but still meet the needs of the Program-level waterfall-style approach.

Agile Approach

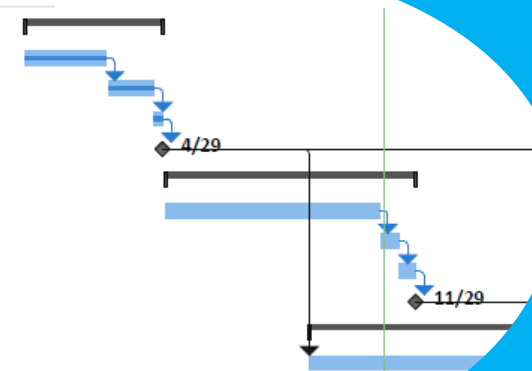


Waterfall Approach

Non-Functional Requirements (1 Requirement Set)
Develop Non-Functional Requirements
Review Non-Functional Requirements
Incorporate Non-Functional Requirements into Model
Non-Functional Requirements Development Complete

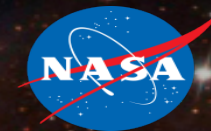
Interface Requirements (1 Requirement Set)
Develop Interface Requirements
Review Interface Requirements
Incorporate Interface Requirements into Model
Interface Requirements Development Complete

Functional Requirements (1 Requirement Set)
Develop Functional Requirements





Questions?



Access to the public-facing Short-Duration Medical System Foundation model can be found here:

<https://www.nasa.gov/hrp/elements/exmc/products>



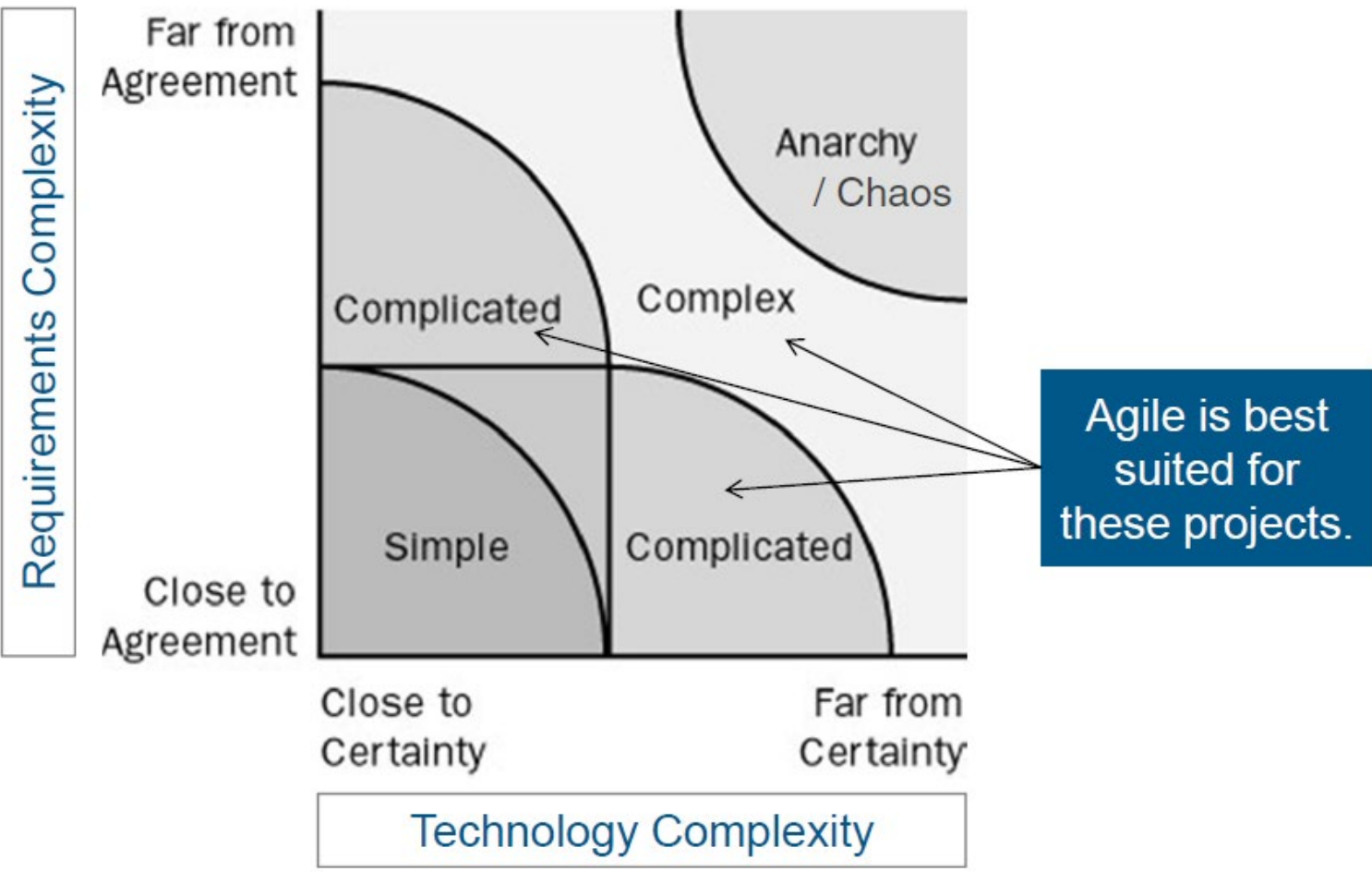


BACKUP





Agile is a hammer



Source: Dave Rice PMP
Dave@DRiceconsulting.com

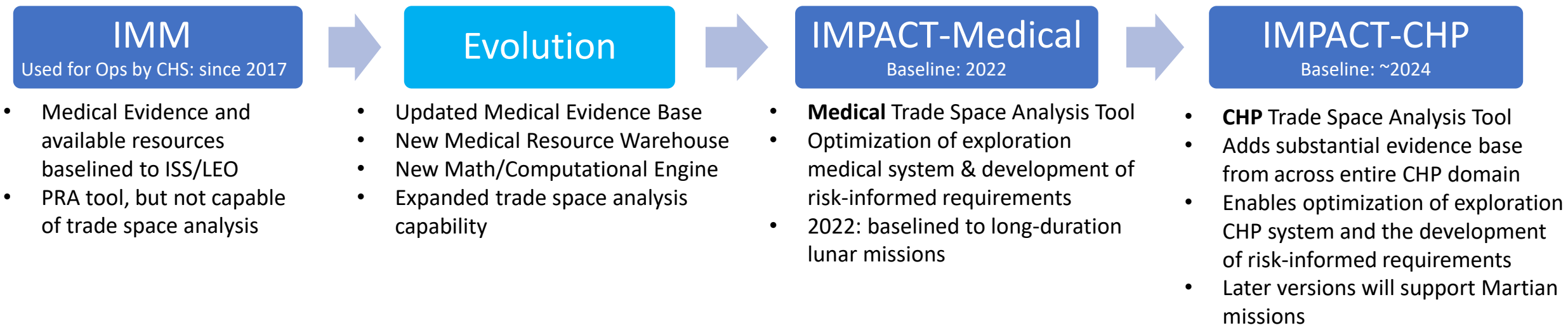


Stakeholders of IMPACT



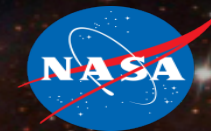
- IMPACT is an ExMC-developed and delivered product with possible stakeholders in other HRP elements and beyond HRP
 - Within ExMC:
 - Systems Engineering (SE)
 - ExMC Leadership Team
 - Broader HRP:
 - Any of the other Elements
 - Program Science Management Office
 - HRP Management team
 - Beyond HRP:
 - Program systems engineering teams
 - Crew health and performance system management
 - Medical system management
 - Office of Chief Medical officer (OCHMO)
 - Medical Operations (MedOps)
 - Crew Health and Safety (CHS)
 - Human System Risk Board (HSRB)
 - Health and Medical Technical Authority (HMTA)
- Stakeholder requirements and deliverables beyond the ExMC element will be captured in customer service agreements (CSA)
- The use case scenarios in the IMPACT ConOps are written with specific stakeholders in mind







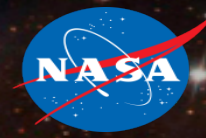
IMPACT: Part of the Evolution of PRA for Crew Health and Performance



- **IMPACT enhances PRA with new capabilities to meet the unique challenges of Exploration missions**
 - Updated and expanded evidence base
 - Consideration of Exploration and deep space environments
 - Updated terrestrial evidence since iMED release
 - Expanded medical condition list
 - Improved modeling of impairment relative to performing mission tasks
 - Accounts for different types of EVA and limited opportunities for RTDC
 - Segmented missions, multiple vehicles



Use cases, DRM and Crew for Demo

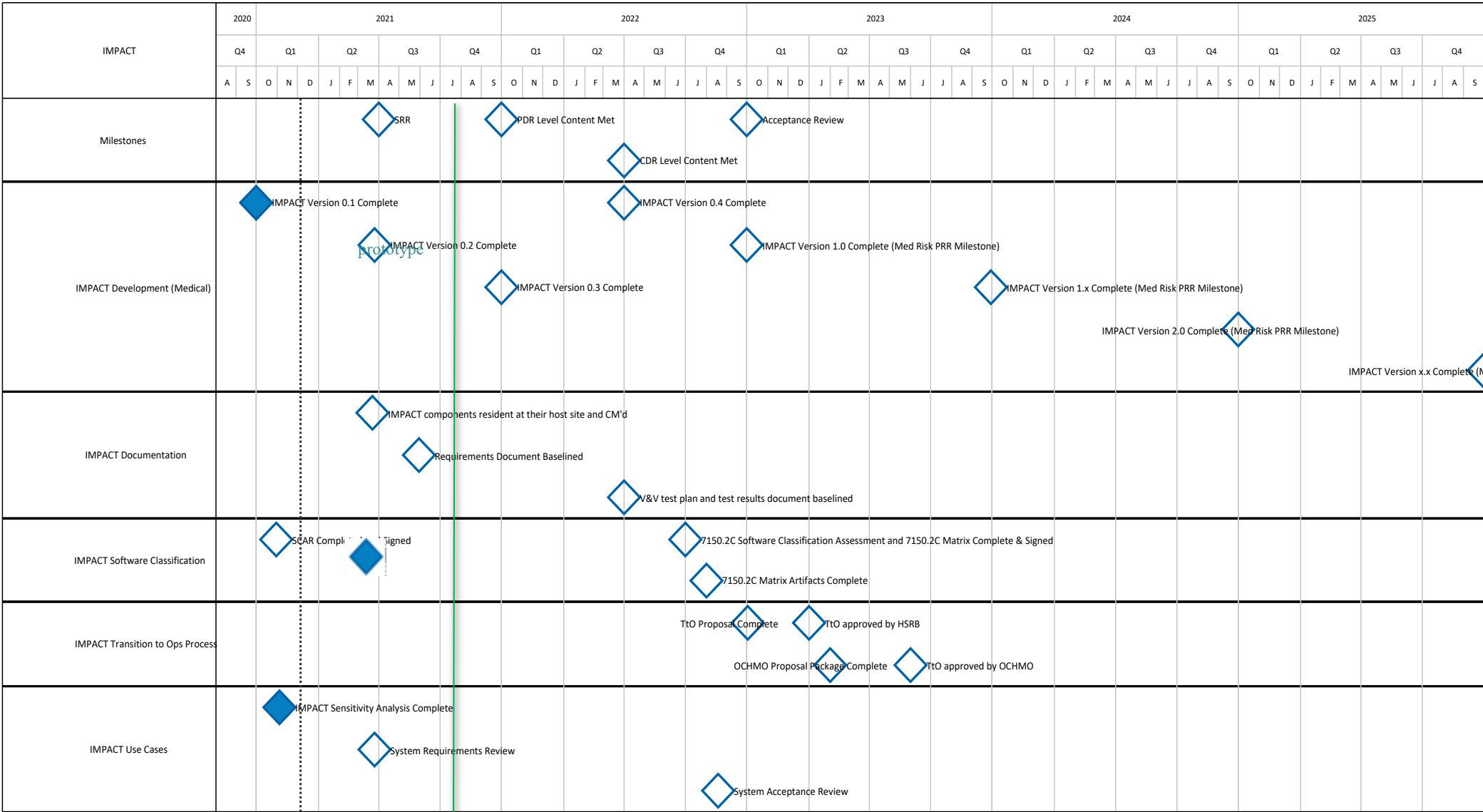


- Use cases
 - Exercise Scenarios 1, 2, 2a, 3 end to end with the tools
 - Use the latest iMED lockdown data LD 68 as input

	April Demo #2	Prototype delivery demo
Duration	42d (Gateway)	365d (1yr Gateway - extended) Meds are assumed not to expire
EVAs	2 EVAs, 25d apart, 6.5h long	8 EVAs, 40d apart, 6.5h long
Crew Members	4 total, 2 female, 2 do EVAs	4 total, 2 male/2 female, 2 do EVAs
Pre-existing conditions	Yes	Yes

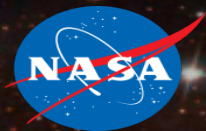


IMPACT Schedule to v1.0 and beyond





IMPACT Development Philosophies



- **IMPACT is an *Agile* software development and integration project**
 - High degree of customer/stakeholder involvement in development
 - Frequent feedback from intended users
 - Monthly sprints with internal demos
 - Quarterly demos with stakeholders
 - Semi-annual version releases
 - While still meeting NASA software engineering (NPR 7150.2C) and computational model (NASA-STD-7009A) requirements
- **IMPACT is using *human-centered design* principles**
 - Aim to make systems usable and useful by focusing on the users, their needs and requirements
 - Apply human factors/ergonomics and industry best practices and user interface standards
 - Conduct usability studies conducted to gather knowledge and an experience base
 - Two human factors specialists are on the project

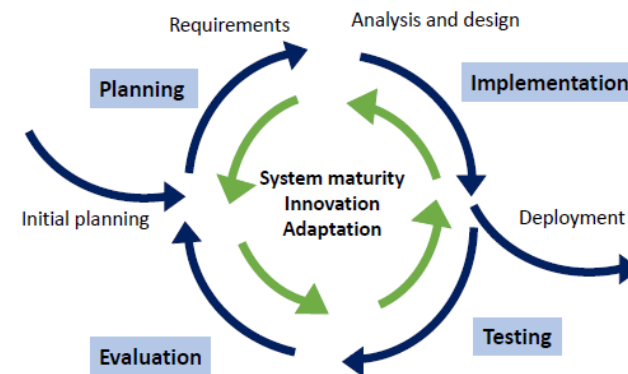
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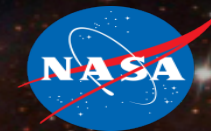
www.agilemanifesto.org

Human Centered Design Approach





AGILE Videos



What is AGILE –Length 11:55

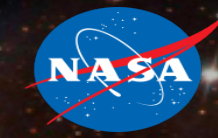
<https://www.youtube.com/watch?v=Z9QbYZh1YXY>

Regular Demos - Length 6:33

<https://youtu.be/Njkek3s3Shs>

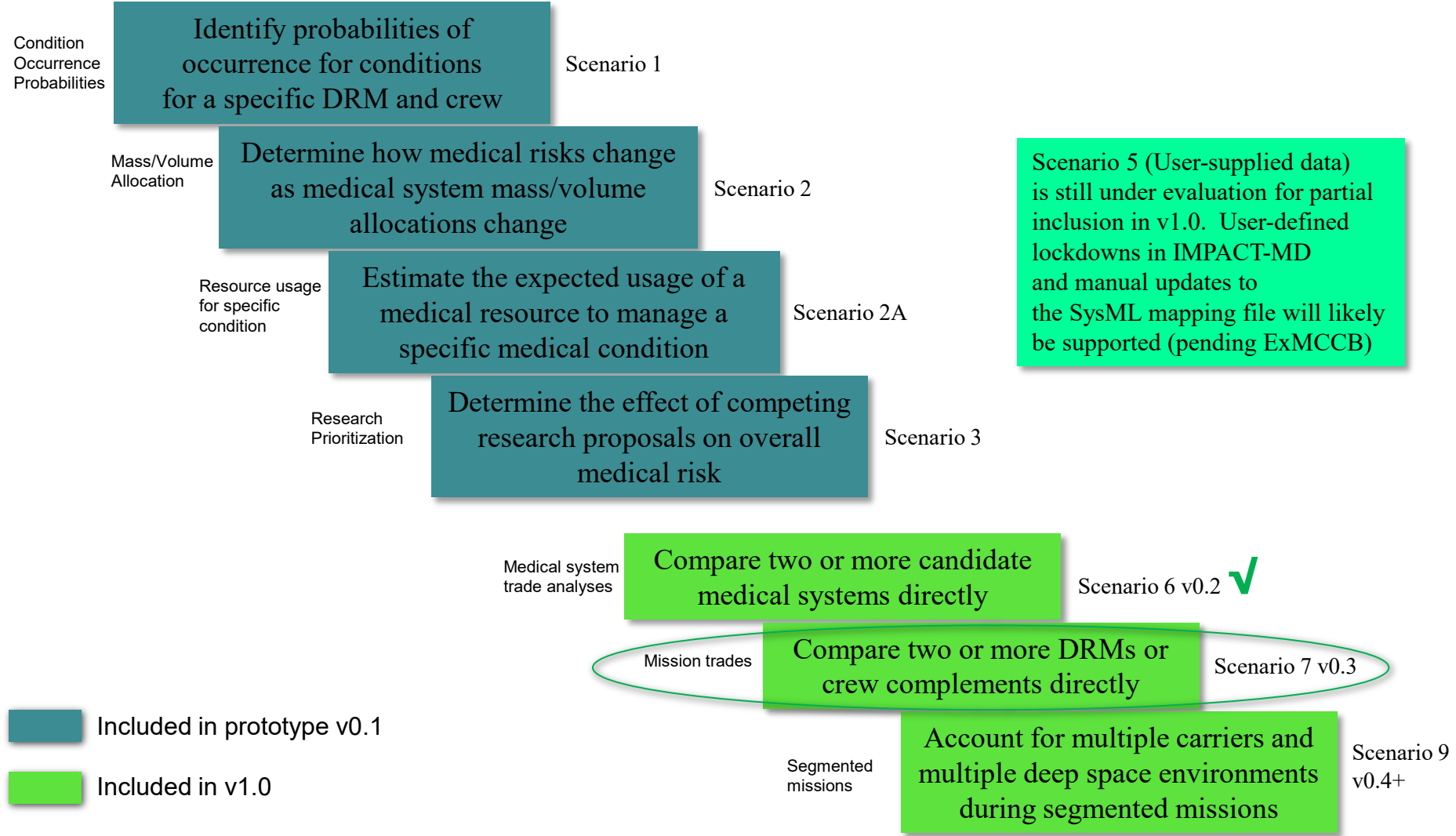
Talk to users 4:20 (Optional)

<https://youtu.be/9WqjReqxAA8>

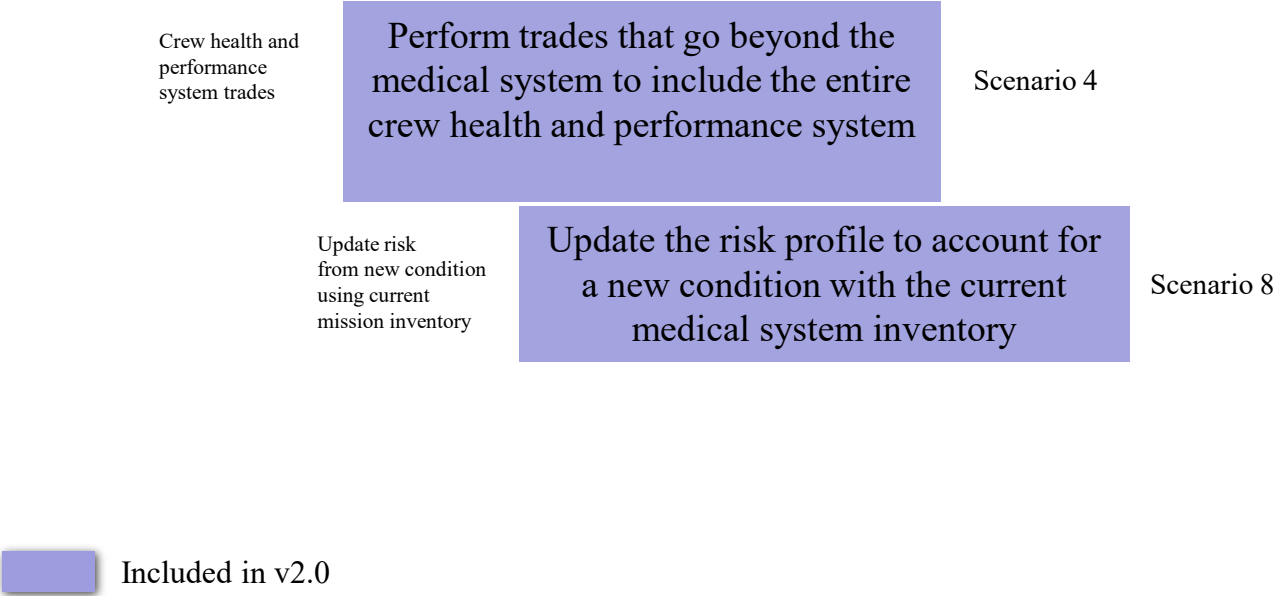


Use Cases for IMPACT 1.0- Con-Ops Scenarios

- This demo will give a status update on how work is progressing on Scenario 7



- The IMPACT ConOps scenarios define the various types of use cases



NOTE: Scenario 5 was deleted